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IS 11632 (1986): Code of practice of rehabilitation of  
tubewell [MED 21: Diamond Core and Waterwell Drilling]

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“Knowledge is such a treasure which cannot be stolen”





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Indian Standard

## CODE OF PRACTICE OF REHABILITATION OF TUBEWELLS

1. **Scope** — Lays down the guidelines for rehabilitation of tubewell.
2. **Introduction** — The useful life of a tubewell depends upon its design, method of construction, type of aquifer tapped, water quality, discharge and depression at which it is operated and the type of maintenance it receives. With the passage of time and continuous pumpage when the yield falls, it may be possible up to a certain stage to restore the well yield or improve its performance by carrying out suitable rehabilitation programme. A well should normally be taken up for reconstruction when its specific yield falls down below 1/2 to 1/3 of the designed specific yield. Also, a tubewell should be taken up for repairs for improvement of discharge, when its specific yield falls to about 80 percent of the initial value.
3. **Cause of Failure** — Tubewell failures are generally indicated either by excessive sand pumpage or steady decline in well yield to the economical pumping. The following are the main causes for the failure of tubewell.

**3.1 Those due to Extraneous Reasons not Connected to Well itself** — In this category are included cases where pumping rate may go down due to lowering of water table in the aquifer as a result of over-pumping or due to interference from other wells in the same aquifer. There is nothing that can be done to the well assembly itself to overcome such difficulties, but it is important to recognize these causes.

### 3.2 Those Arising from Damage to the Tubewell itself

**3.2.1 Incrustation and corrosion** — Depends upon the chemical quality of the water. Corrosion is a chemical action of water on metals which results in eating away or removal of material from the surface. It may severely limit the life of a tubewell by enlarging slot openings, leading to sand pumping, reduction in strength followed by collapse of screen and re-de-position of corroded products causing blockage of screen openings.

Incrustation results from clogging of the aquifer around the well and openings of the screen, leading to decrease in well capacity.

If pH of the well water is more than 7.50, it is indicative of incrustive nature. Carbonate content higher than 300 ppm causes incrustation due to carbonates of calcium and magnesium. Iron content from 2.0 to 3.0 ppm and manganese content higher than 1.0 ppm tend to cause incrustation. If pH value of the well water is less than 7.00, it is acidic in nature and may have corrosion effects. If presence of carbon dioxide exceeds 80 ppm, the water is expected to be corrosive. Presence of chloride content more than 1000 ppm, hydrogen sulphide 1 to 2 ppm and total dissolved solids over 1000 ppm is indicative of corrosive nature of water.

**3.2.2 Over pumping** — Over pumping is usually caused due to clogging of well screen or water bearing formations, as a result of accumulation of fine sand particles adjacent to the well screen. This leads to increased draw down and may eventually cause rupture of the strainer. Whenever increased draw down is noticed accompanied with pumpage of fine sand, the rate of pumping shall be reduced down and balanced against rate of replenishment.

**3.2.3 Improper design and gravel placement** — It included failures due to improper design, faulty placement of pack materials and improper development of the well. Gravel pack gradation and screen slot size in many cases are not properly matched to the aquifer grain size leading to formation of voids.

Faulty placement of gravel results into segregations by particle size and also causes bridging or knotting in gravel pack at one or more places. This defect, if left unnoticed, by not ensuring continuity of the gravel pack during development, causes irreparable failure of the tubewell. As the well is run, gradual development takes place in starts and gravel below and bridged portion moves down, causing exposure of the slotted portion to the aquifer, directly against it. This results in free flow of aquifer material into the well pipe, causing sand filling and consequent reduction in well yield.

In agriculture strainer type wells incorrect size of mesh openings may either lead to clogging of the strainers resulting in loss of discharge or continuous flow of sand with water followed by cavity formation, which on sudden collapse may cause sinking of the pump house building. Not much can be done to avoid such failures due to faulty design or incorrect size of gravel or mesh openings. However, sometimes formation of cavities around the screen allow the overlying fine material to settle down and get positioned against the screen performances. This reduces the well yield and again, when the so placed material is washed off, the discharge increases. This phenomenon is indicated by erratic performance of the well.

**3.2.4 Faulty construction** — Failures due to deficiencies in tubewell construction methods and in construction inspection such as faulty or loose pipe and screen connections or joints are rare. This is indicated by sudden heavy rush of sand into the well pipe. To locate and rectify such defects, it is best to take sounding of the well and compare the sand discharged with the original well logs. The well may be cleared up with a bailer.

If not substantial portion of the slotted pipe or screen is likely to be lost, it is best to plug the portion up to the defective joint. It would, of course, reduce the well yield in proportion to the length of the screen lost.

#### 4. Information to be given by User

**4.1** The causes of the sickness of a well shall be diagnosed before any remedial measures are adopted. The condition of the well may be judged from the performance data during its service life. Following information shall be made available by the owner:

- a) Initial and present well yield, depression, spring level as observed periodically during the well's service life.
- b) Sand content in ppm, if any.
- c) Grain size distribution of the strata taped as a result of sieve analysis.
- d) Location of screen, its opening size, percentage of screen surface area to the total open area, screen material length and diameter of screen and well pipes, etc, and data of acceptance of the well.
- e) Size and quantity of pea-gravel used initially and during its service life.
- f) Method used and details of development with results.
- g) Method of drilling adopted, name of drilling agency, original pump and well test results and results of subsequent tests, if available.
- h) Results of the initial and present chemical analysis of the well water.
- i) Details of any chemical treatment, if ever given to the well and results achieved therefrom.
- k) Sounding of the well assembly observed every year.
- m) Details of repairs to the pumping equipment carried out every year.
- n) Number of electricity units consumed per kilowatt ratings every year during service life of the well.

#### 5. Investigations to be Carried out by the Contractor

**5.1** The following data shall be determined for reference when starting rehabilitation on any well:

- a) Date of acceptance of well
- b) Name of contractor
- c) Method of drilling
- d) Method of formation sampling
- e) Formation log
- f) Mechanical analyses of aquifer samples
- g) Mechanical analyses of pack material

- h) Screen materials, slot sizes, diameters and depth of setting
- j) Present open area of screen, design inflow velocity
- k) Depth, diameter and material of pump chamber
- m) Method and completeness of development
- n) Original pump and well test results and results of subsequent tests, with dates
  - 1) Static water level
  - 2) Measured depth to bottom of hole
  - 3) Discharge
  - 4) Draw down
  - 5) Specific capacity
  - 6) Step tests
  - 7) Production tests
- p) Ground water hydrographs of area
- q) Quality of water analyses of well with dates
- r) Resume of maintenance, rehabilitation and performance
- s) Similar data shall be collected by the electrical division on each pump unit.

**5.2** The following investigations shall be carried out and data determined before starting rehabilitation on any well:

- a) Ground water hydrographs of the area, if available
- b) Chemical and bacteriological analysis of the well water shall be carried out and compared with the original one, with regard to its original and the present apparent incrustation potential.
- c) If the well is yielding sand, the discharged sand sample shall be collected and compared with the original formation log so as to locate precisely the position of the possible rupture or loose connection, etc.
- d) If equipment is available, an under water photographic survey shall be carried out and location of any evidence of incrustation, organic growth or accumulation on the casing and screen recorded. Also, any filamentous algae, iron bacterial or similar organisms floating in the water shall be noted. Any evidence of mechanical damage to the casing and screen shall be carefully inspected with the camera and recorded with regard to its description and depth.
- e) The present specific yield at a design discharge rate and draw down low enough to permit continuous pumping for 4 hours, without breaking suction, shall be determined. This will give a qualitative measure of the degree of deterioration and by comparison with the later tests, the success of rehabilitation programme.
- f) The pump be pulled out and various parts be examined immediately as they are removed from the well. The column pipe, drive shaft, bearing spiders and bowl shall be inspected for evidence of excessive accumulations or deposits of ferric or ferrous hydroxides. If the deposits are present, sufficient samples shall be collected to fully fill a bottle capable of being sealed airtight. This shall be done as rapidly as possible and the samples sent to the laboratory immediately, so to avoid generation of heat in the sample. The samples shall be sent to the chemical and biological laboratories for identification of chemical and biological laboratories for identification of chemical compounds present and identification, if possible, of organism involved.
- g) Examine pump parts for evidence of pitting, tuberculations, graphitization, cavitation and wear. Pump bowls and impellers shall be inspected for evidence for graphitization in areas where sulphate bacteria are known or suspected to be present.
- h) The static water level and depth of the bottom of the well assembly shall be checked again out of the well when the pump is taken out of the well.

**5.3 Remedial Measures** — After the causes of well failure or sickness are established on the basis of the performance and other data, appropriate remedial measures, as detailed in subsequent para, may be adopted. In case reduction in yield is found to have been caused due to some sort of pump failure, the obvious remedy is to repair or replace the pump. In all such cases, it is a good practice to observe sounding of the well and compare it with the original one.

## 6. Preliminary Steps for Well Rehabilitation

**6.1** Usually a well shall not be rehabilitated until the specific capacity has decreased 15 percent or more. The proposed rehabilitation shall usually involve pulling of the pump.

Prior to any field activity, analyses of water from the well as initially completed and at present shall be examined in regard to its original and present apparent incrustation potential. If it is high or has increased in time, possibly two acid treatments may be required and provision shall be made to have the required material available, if needed.

If records on the kwh used by the well, the hours of operation, or the volume of water pumped are available, they shall be examined. Other things being equal (which they seldom are), the amount of incrustation or fine invasion of the pack will vary with the volume of water pumped, the hours of operation, or similar measure of well use.

Data on the initial static water level, the present water level the specific capacity at design discharge and the present specific capacity at a discharge rate and draw down low enough to permit continuous pumping for 4 hours without breaking suction shall be obtained. This shall give a qualitative measure of the degree of deterioration and by comparison with later tests the success of the rehabilitation programme. When the pump is pulled, examine the various parts immediately as they are removed from the well. The column pipe, drive shaft, bearing spiders, and bowl shall be inspected for evidence of excessive accumulations or deposits of ferric or ferrous hydroxides. If present, sufficient samples shall be scrapped off for laboratory examination to fully fill a bottle capable of being sealed airtight. This shall be done as rapidly as possible and the samples sent to the laboratory immediately, since the oxidation and loss of original character of such material when exposed to the air, temperature change, and drying is at times of rapid as to generate sensible heat in the sample. Pump parts shall subsequently be cleaned thoroughly and examined for evidence of pitting, tuberculation, graphitization, cavitation, and wear by the machine shop. Any necessary repairs, replacements, or adjustments shall be made while the well is being worked over. The samples scrapped from the pump shall be submitted to the chemical and biological laboratories for identification of chemical compounds present and identification, if possible, of organisms involved. Pump bowls and impellers shall be inspected for evidence of graphitization in areas where sulphate reducing bacteria are known or suspected to be present.

The static water level and depth of the bottom of the hole shall be checked again with the pump out of the well.

If equipment is available, a TV camera survey shall be made of the well and the location of any evidence of incrustation, organic growth or accumulation on the casing and screen recorded. Any filamentous iron bacterioplankton or similar organisms floating in the water shall be noted. Any evidence of mechanical damage to the casing and screen shall be carefully inspected with the camera and recorded in regard to description and depth.

Identification of organisms that contribute to well deterioration is not primarily important initially since it is probable that they may be controlled by presently practiced chlorination or their sterilizing procedures. However, these shall be studied and identified eventually as part of the overall investigation since such knowledge may lead to more effective or less expensive methods of control.

## 7. Methods of Rehabilitation

**7.1 Glossy Phosphates Treatment** — Polyphosphates are used to disperse clays and silts, and loosen their adhesion to sand and gravel so they may be more readily drawn into the well during development. They are seldom used alone but usually in conjunction with a wetting agent, sodium carbonate and a chlorine compound. The wetting agent facilitates the penetration of the polyphosphate solution into the fine grained materials and hastens the operation. The sodium carbonate has a cleaning action towards rust on iron screens and pipe, and also serves to neutralize the effects of oil and other organic compounds that might interfere with the action of the chlorine. The chlorine acts somewhat as a catalyst and seemingly improves the action of the polyphosphates as well as acting to sterilise the well and adjacent formations.

However, until more is known of the fabric and composition of the aquifers, it is recommended that wetting agents be omitted from the solutions. Under some circumstances the wetting agents cause too rapid a breakdown of some clays and a drastic breakdown of the fabric. As a consequence, aquifers are sometimes too tightly blocked to be adequately developed by any means.

Also in wells screened with fibreglass-reinforced epoxy, the sodium carbonate may probably be left out of the solution without its losing efficiency.

When first applied to water well development, the use of 13 to 18 kg of polyphosphates per 450 litre of water in the well was used. With experience, this was found to be an unnecessarily strong solution for most wells. On the other hand, it was found that all wells did not respond similarly and that the desirable concentration might range from 2.3 to 9 kg of polyphosphate per 450 litre of water in the well. Initially it is suggested using 3.6 to 4.5 kg hexometaphosphate per 405 litre of water in the wells. Experimental increases or decreases about 900 g each may show better performance with a greater or less concentration, but it shall be determined only by experiment.

While the percent of chlorine compound in the solution appears to improve its action, if the amount of chlorine present is at least 50 ppm. Larger concentrations do not seem to either impede or improve the effects of the solution. Consequently, chlorine may be used with polyphosphates either as a normal sterilizing agent or in shock treatments designed to oxidize and destroy not only the organisms but the inanimate products of their metabolism that act to block packs and screens.

In view of these considerations and the probable nature of the aquifers and blocking materials in the screen, the initial procedure in rehabilitating any well is as follows:

Estimate the volume of water in the pack and screen between the water table and the bottom of the hole to the nearest 450 litre. On the basis of the following amount of reagents per 450 litre of water in the well, estimate the amount of various chemicals required:

- a) For fibreglass reinforced epoxy screens — Sodium hexametaphosphate 3.6 kg; available 100 ppm
- b) For metal screens — In addition to the above 900 g sodium carbonate
- c) Should experience show use of a wetting agent is helpful 450 g pluronic F68 or equivalent.

Most wells contain between 10 900 to 15 900 l of water. A wooden or black iron tank  $1.2 \times 1.5 \times 3$  m is a convenient size for transportation, etc, and holds in excess of 6 360 litre of water. Therefore, two or three batches of solution mixed in the tank shall be required for each well. A convenient but not necessary arrangement that speeds up the operation is to use two tanks in order that the next batch of solution may be mixed while the previous one is being placed in the well.

The solution is poured or pumped into the well through a 38 to 50 mm plastic or black iron pipe that initially is installed from the surface to about 1.5 m above the bottom of the well. Sufficient solution is put in the well to displace an estimated 1.5 or 3 m of the water in the casing and pack. The pipe is then raised 1.5 or 3 m and the procedure repeated until all water in the well and pack are displaced by the solution. The solution has higher specific gravity than the water and displaces it upward and outward from the well. When all the solution is installed in the well, a volume of water equal to about one-half that contained in the casing and screen is pured in at the top to displace the solution from the screen and force it out into the formation (see Table 1). A 200 m casing contains about 11 litre and 200 mm screen about 18 litre of water per metre of length. A surge block bail or similar tool is then run from the bottom of the well to above the water table two or three times of the inductor pipe for air surging may be replaced to near the bottom of the well and air bubbled up through the well to thoroughly mix the solution remaining in the casing screen.

TABLE 1 LITRE PER 300 mm OF LENGTH—CONTENTS OF CASING AND SCREEN  
(Clause 7.1)

Nominal Pipe Size

mm	/
100	3.0
125	4.6
150	6.8
200	12.0
250	19.0
300	26.4
350	32.2
400	43.0
450	54.0
500	67.0
550	81.8
600	98.0

Allow the solution to remain in the well for a minimum of 6 hours, overnight is a commonly used period, during which the well is surged about every hour by running the surge block from the top of bottom of the water column in the well three or four times at a moderate speed or by surging with air.

**7.2 Acid Treatment** — One of the most commonly used acids for treatment of well is 27.92 percent hydrochloric acid. The acid is used full strength usually in a volume sufficient to displace 1.5 to 2 times the volume of water in the casing, screen, and gravel pack between the bottom of the well and 3 m above the topmost screen slot. The acid is poured into the well through a black iron or plastic pipe 38 to 50 mm in diameter which extends to the bottom of the well. The estimated volume of acid required to displace the water from 1.5 to 3 m section is poured in. The acid has a higher specific gravity than water. Then the pipe is lifted 1.5 to 3 m and the process repeated until all the acid is added to the well. During pouring of the acid, 900 g of chelating agent per 4.5 litre of HCl shall be poured down the pipe. Citric acid, Rochelle salts, tartaric acid, phosphoric acid, and glycolic acid are acceptable chelating agents. Muriatic acid dissolves iron compounds when at a pH lower than 3 but as the acid reacts with the carbonates the pH rises to 3 and insoluble ferrous hydroxide precipitates from the acid. The chelating agents tend to keep the iron in solution regardless of the pH so the iron can be pumped from the well with the spent acid, rather than remaining as a contaminant to block the pack.

In metallic casing and screen, an inhibitor such as knox gelatine is added to the acid in the amount of 2.3 to 2.7 kg dissolved in warm water per 450 litre of acid to control attack on metal parts. However, there are no such parts in a fibreglass reinforced epoxy well so this is unnecessary when treating such wells.

The acid remains in the well for 4 to 6 hours. At the end of about 3 hours sufficient water is added to the well to displace the acid from 3 m above the topmost slot to the bottom of the well. While the acid is in the well and pack of the well is surged by air or with the surge block for 15 to 20 minutes each hour. At the end of about 6 hours, the acid is bailed or pumped out.

Use of hydrochloric acid is quite dangerous for inexperienced crew members. The acid gives off dangerous poisonous fumes and the reaction with the carbonates in a well is sometimes violent, resulting in spraying the bystanders around the well. In addition, the transportation of the liquid hydrochloric acid to the field is difficult and sometimes dangerous. For these reasons sulfamic acid is becoming more popular for well rehabilitation. Sulfamic acid is more expensive but is easily shipped as a dry crystal or powder. It is not as aggressive or strong as hydrochloric acid and is generally much safer to use. It requires about two times as long to treat a well as does hydrochloric acid.

When using sulfamic acid in a well, the same estimates are made regarding the column of water in the well to be displaced and 1.5 to 2 times that volume is poured into the well through a black iron or plastic pipe as described in the discussion on hydrochloric acid. It is available in granular form and may be poured into the well from the top.

Because sulfamic acid is a milder and less aggressive acid, it is mixed in a black iron or wooden tank at the surface. A tank about 1.2 x 1.5 x 3 m is usually adequate and holds about 6360 litre. The tank shall have a bottom valve through which the acid solution is drawn into the well. 41 kg sulfamic acid, 450 g of pluronic F68 and 2.7 kg chelating agent such as Rochelle salts, citric acid, tataric acid, etc, are added and dissolved in each 450 litre of water to be poured into the well. If well is screened with metal, an inhibitor such as knox gelatine shall be used at the rate of 1.8 to 2.3 kg per 450 litre of solution. The acid shall remain in the well for at least 12 hours during which it shall be surged by air or surge block about 15 to 20 minutes every hours. Then it is bailed or pumped to waste.

Hydrochloric acid of adequate strength is readily available at a relatively low price. It is used successfully safety precautions that no injuries or casualties have resulted. Under the circumstances, it appears that hydrochloric acid, despite the danger and difficulties associated with its use, shall continue to be used. However, if the programme expands to the point where trained and experienced crews are not available to carry on the acidizing work, consideration shall be given to employing the less dangerous sulfamic acid.

The spent acid is bailed or pumped out of the well using a corrosion-resistant pump for the purpose. In many wells, pumping with a centrifugal pump shall be possible. Close observation of the bailing or pumping discharge and the draw downs during removal of the acid shall give an indication of the success of the treatment.

During acid treatment of a well the crew shall wear protective clothing and respirators. One or two 250 litre drums of concentrated sodium bicarbonate shall be available for quick neutralization of acid with which crew members may come in contact during the operation.

During treatment, incrustation is dissolved and the fines incorporated in the agent remain in the pack and base material. On completion of acidizing the well shall be redeveloped using polyphosphates, sufficient chlorine for a shock treatment and one of the methods of surging or jetting.

**7.3 Chlorine Treatment** — In some localities where the bacterial growth or slime have clogged the water bearing formation, the treatment with chlorine has been found effective. The disinfection or burning up of the organism slime is accomplished by hypochlorous and hypochloric acids, which are formed when chlorine is added to water.

The chlorine shall be handled carefully with the aid of suitable containers and piping to ensure proper placement, as it is highly corrosive in the presence of water. When incrusted wells are heavily treated with chlorine, It shall be followed by dechlorination with sulphur dioxide.

For chlorine treatment, a concentration of 100 to 200 ppm of free chlorine is required, sufficient amount of calcium hypochlorite sodium hypochlorite is put into the well either directly or in a water solution so as to give the required concentration of chlorine, alternatively chlorine gas is used in solution with water. The solution shall be introduced in the well through a small diameter plastic pipe. A quantity of chlorine, 14 to 18 kg, added slowly over a period of 12 hours, shall suffice to produce good results in a large well. After adding chlorine solution, it shall be forced out into the water bearing formations by adding considerable amount of water. About 50 to 100 times the volume of water standing in the well shall be used for this purpose.

The well shall be surged or solution agitated as is done in case of acid treatment.

**7.4 Dry Ice Treatment** — The use of dry ice, that is, solid carbondioxide is still in the experimental stage. Dry ice changes from solid to gaseous state rapidly with considerable pressure, when put into well water. The rapidly expanding gas is confined within the well casing and is forced through the screen openings to loosen the clogged material. On account of high pressure developed, provision shall be made for the control and relief of pressure to guard against any damage. As dry ice may cause severe burns, if handled with bare hands, heavy gloves or tongs shall be used in handling the ice.

**7.5 Explosives** — These are sometimes employed to develop and enlarge crevices and fissures in tubewells drilled in hard rocks. Charges of 30 to 500 ppm are used according to the hardness of the rock and the depth at which the charge is to be detonated.

## 8. Criteria for Acceptance

**8.1** An increase in yield of the well by 30 percent of the pre-rehabilitated yield of the well or attainment of 75 percent of the initial yield, whichever is more, shall be the basis of acceptance. Alternatives, it may be agreed to between the contractor and the owner.

## 9. Information to be Supplied by the Contractor to Owner for Future Use

**9.1** The contractor shall supply the following information to the owner for future use:

- a) Results of the investigations carried out before taking up work of rehabilitation.
- b) Result of chemical tests carried out before and after rehabilitation work.
- c) Methods used alongwith name and quantity of chemicals used and number of treatments given.
- d) Results of rehabilitation, that is, discharge, depression and sand content in ppm at start and after 20 minutes.
- e) Sounding of the well after the treatment.
- f) Condition of the pumping unit before rehabilitation and details of repairs carried out to it.
- g) Suggestions, based on investigations, for future upkeep and maintenance of the well including recommended limit to continuous discharge and depression, that is, rate of pumping in order to avoid harmful over pumping and thereby limiting the entrace velocities.
- h) Any other relevant information desired by the owner.